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August 19, 2008
Project No. 8128.01.20

Mr. Dana Bayuk
Oregon Department of Environmental Quality
2020 SW 4th Avenue, Suite 400
Portland, Oregon 97201-4987

Re: Addendum to the Enhanced Bioremediation Source Control Work Plan – Phase I Injection Plan
Siltronic Corporation
7200 NW Front Avenue, Portland, OR
ECSI #183

Dear Dana:

The following letter provides the design basis for Phase I of the enhanced in-situ bioremediation (EIB) to be implemented in the TCE source area at the Siltronic Corporation (Siltronic) facility in Portland, Oregon. This document is an addendum to the *Enhanced Bioremediation Source Control Workplan* (the Workplan) prepared by Maul Foster & Alongi, Inc. (MFA) on behalf of Siltronic, and submitted to the Oregon Department of Environmental Quality (DEQ) on May 12, 2008. Additional addenda will be submitted for subsequent phases of work, as needed.

This document includes a focused data submittal that will allow DEQ to evaluate Siltronic's proposed plan to move forward with Phase I of the injection without delay. The phased injection approach allows for periodic adjustments during the injection process, such that additional injection phases can be tailored as appropriate. Timely implementation of Phase I will further the goal of coordinating source control efforts by helping to reduce the amount of potential F002-listed waste requiring treatment by NW Natural's riverbank pump and treat system

This document provides: (1) a summary of the source area delineation work; (2) estimates of lateral and vertical extent of trichloroethene (TCE) where concentrations exceed one percent of the solubility limit; (3) an injection plan, including the alignment for a proposed permeable reactive barrier (PRB) injection zone; (4) proposed locations for performance monitoring wells; and (5) an implementation schedule. The delineation summary, which estimates the lateral and vertical extent of TCE (and its degradation products) in the subsurface, presumes the establishment of an injection threshold of

11,000 ug/L TCE identified by DEQ in their February 14, 2008 letter, which provided comments on the EIB Pilot Study Report.[1]

In an email dated July 27, 2008[2], DEQ stated that they conceptually supported the change from a “saturation approach” to a permeable reactive barrier (PRB) approach for source area treatment. This submittal provides the additional information requested by DEQ as justification for the PRB approach.

DELINEATION SUMMARY

The source area delineation work included reconnaissance groundwater sampling for TCE and its degradation products (specifically, cis-1,2-dichloroethene (DCE), DCE isomers, and vinyl chloride); pneumatic slug testing for hydraulic conductivity, lithological observations, and soil permeability testing. The work was completed consistent with the *Pre-Injection Scope of Work* submittal by MFA[3] as modified in accordance with DEQ’s comments in their email dated June 20, 2008.

Reconnaissance groundwater samples were collected from 17 boring locations at multiple intervals using direct-push methods. The locations are shown on Figure 1. Samples were collected consistent with procedures identified in documents previously approved by DEQ[4], and were submitted to Specialty Analytical (SA) of Tualatin, Oregon for volatile organic compound (VOC) analysis by US Environmental Protection Agency (EPA) method 8260. A total of 42 pneumatic slug tests were completed at selected groundwater sampling intervals. At DEQ’s request, three borings were continuously logged for lithology, and soil samples were collected for permeability testing. The following sections describe the results.

Lithology

Boring logs for GP-111, GP-112, and GP-113 are included as Attachment 1. While significant heterogeneity exists in the subsurface (as expected), the following statements generally characterize the lithology in the source area:

- Sandy fill was observed from 0 to 20 feet below ground surface (bgs).

[1] Submitted to DEQ on August 9, 2007.
[2] Bayuk, D. email correspondence to James Peale re: Siltronic, Former UST System Delineation Data and Phased EIB Scale-up
[3] Submitted to DEQ on April 17, 2008.
[4] Including the RI Workplan, submitted to DEQ on September 17, 2004.

- Silt underlying the fill was observed from approximately 20 to 40 feet bgs.
- Sand and silty sand mixtures were observed from approximately 40 to 110 feet bgs.
- A silt layer, previously observed during completion of WS-13-69/105, was identified in borings GP-111 and GP-112, but not observed in boring GP-113.

The results are consistent with previous borings.

Slug Test Results

Pneumatic slug tests were performed at selected depth intervals in the borings. The slug-test data were analyzed using AquiferTest Pro software, with the Bouwer & Rice method (Bouwer, 1989). Plots of the analytical reports are included in Attachment 1. The results are summarized in Table 1. The hydraulic conductivity (*k*) values ranged from 0.19 to 60.47 feet per day; the mean was 7.03 feet per day.

Based on these data, the average linear groundwater flow velocity (*v*) was calculated using the following equation:

$$v = \frac{k}{\theta} * i$$

where

k = hydraulic conductivity (varies, based on results of pneumatic slug testing)

θ = effective porosity (assumed to be 0.3[5]) and

i = horizontal gradient (0.007).[6]

Table 1 summarizes the results of the *v* calculations. Overall, the results ranged from 0.0046 to 1.15 feet per day, with a mean of 0.13 feet per day. Slug tests at a given boring location were typically performed at more than one depth, and exact depths varied slightly from boring to boring. Slug test results were compared by grouping into intervals with similar lithologic characteristics.

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[5] Based upon ranges presented in Freeze and Cherry, 1979.
[6] Mean gradient calculated using groundwater elevation data from monitoring wells WS-13-69/105, WS-19-71/101, and WS-18-71/101 collected from September 2006 through June, 2008 and as submitted to DEQ in monthly progress reports.

Table 2 shows the average linear velocity results in aggregate and per depth interval. Slug test results indicate that groundwater velocities are higher in the shallow portion of the aquifer (approximately 25 to 35 ft bgs), with an average of 0.71 ft/day. Groundwater velocities in the lower portion of the aquifer (from approximately 50 to 115 ft bgs) are an order of magnitude slower, at a mean of 0.079 ft/day. The overall mean of the slug testing data is 0.134 feet/day.[7]

The groundwater flow velocity data are helpful for estimating remediation time frames. The estimated mean groundwater flow velocity in the source area of 0.13 feet per day is a reasonable but conservatively low value. That value is not, however, representative of flow velocities further downgradient, which are on the order of 1-2 feet per day. It is understood that slug tests (especially when conducted in aquifers with significant silt size fractions) tend to underestimate hydraulic conductivity.[8] For the purposes of understanding site-wide travel times, a flow velocity ranging from 0.13 feet per day in the source area to 1-2 feet per day downgradient of Fab 1 appears to be appropriate and is consistent with previous estimates.[9]

Flexible Wall Permeability Test Results

Samples for flexible wall permeability testing were obtained from GP-112, GP-113, and GP-114 at a selected depth interval at the bottom of the borings. The samples were retained in the direct-push macrocore casing and sent to Northwest Testing, Inc. of Wilsonville, Oregon. MFA observed the opening of the cores at the lab and selected sample locations representing the confining silt unit. Samples for testing were selected at 103.5 feet bgs in GP-112 and 108.5 feet bgs in GP-113. Silt was not observed in the core sample obtained from GP-114.

Samples were analyzed by the lab using a flexible wall permeameter using ASTM Method D5084. The mean permeability was 2.49×10^{-7} cm/s in GP-112, and 1.07×10^{-6} cm/s in GP-113. Laboratory results are contained in Attachment 2.

These results indicate that hydraulic conductivity of the silt unit is orders of magnitude lower than the overlying silty sand containing groundwater impacted by TCE and its

[7] It should be noted that most of the lower aquifer data were consistent; however, there were a few outliers that had higher v values. The outlying data did not significantly affect averages given the number of data points collected.
[8] Butler, J.J. & Healy, J.M; *Relationship between pumping-test and slug-test parameters: scale effect or artifact?*; Ground Water, Vol. 36:2. 1998.
[9] E.g., as presented in the Pilot Study report.

degradation products. TCE and its degradation products were not detected in the soil samples collected from the silt unit. The soil data are confirmed by the groundwater samples from similar elevations, and while the silt unit may influence groundwater flow, groundwater impacted by TCE and its degradation products has not migrated into or below this potential lower confining unit. The absence of the silt unit in boring GP-114 does not significantly alter the conceptual site hydrogeologic model.

Groundwater Analytical Results

Groundwater analytical data from the borings are summarized on Table 3 and shown on Figure 2. The data show that TCE is present above the injection threshold (11,000 ug/L) primarily between approximately 50 and 100 feet bgs downgradient of the former UST area, at concentrations ranging as high as 448,000 ug/L in GP-110-70. TCE is also present between approximately 30 and 75 feet bgs upgradient of the former UST area, at concentrations ranging as high as 269,000 ug/L in GP-124-30.

In both areas, the lower vertical extent of TCE above the injection threshold was sharply bounded, with concentrations dropping by orders of magnitude within relatively short (i.e., tens of feet) vertical distances. The lateral extent is similarly sharply bounded, as is apparent from data collected at comparable elevations at from GP-111/GP-118; GP-117 and GP-124 (compared to GP-119); and GP-116/GP-121.

These data are consistent with concentrations in samples collected in advance of the pilot study. No groundwater samples contained TCE at concentrations exceeding the concentrations measured in 2006 (prior to pilot study implementation[10]) or during previous investigations in 2003 and 2002, which suggests that scaling up of the pilot study has a high probability of success.

With respect to degradation products, cis-1,2-DCE was consistently detected in samples with TCE detections, at concentrations comparable to the pre-pilot study investigation and quarterly data collected from WS-13-69. Other DCE isomers (trans-1,2-DCE and 1,1-DCE) were also detected, but at concentrations orders of magnitude lower. The

[10] Reconnaissance groundwater samples were collected in the source zone pilot study area prior to installation of the pilot study EIB PRB; the maximum concentration of TCE in groundwater was 592,000 ug/L.

production of cis-1,2-DCE confirms the ongoing microbial degradation of TCE in the source area, since cis-1,2-DCE is primarily a biological degradation product.[11]

Vinyl chloride (VC) data were consistent with the quarterly data from WS-13-69, and were mostly non-detect or very low relative to cis-1,2-DCE and TCE. By comparison to TCE and cis-1,2-DCE, virtually no VC is being produced in the source area, except within and downgradient of the pilot study PRB, where concentrations as high as 27,600 ug/L were detected. Again, the reconnaissance data are consistent with concentrations detected during the delineation performed prior to the pilot study, confirming that the EIB PRB approach has a high probability of success.

Laboratory analytical reports and validation memo are included in Attachment 3.

Consistency with Conceptual Site Model

The detections upgradient of the former UST area are shallower than expected, and may represent a separate, discrete release of TCE that was not indicated by earlier data. Based on the locations and concentrations, it appears that a release in the unpaved area near GP-123 may have occurred, apart from the previously-documented release (or releases) near the former UST area, which is approximately 40 feet downgradient. Groundwater impacts from this new potential release area appear to have contributed to the deeper impacts observed downgradient of the former UST area, as discussed below.

These detections necessitate further investigation, but do not represent a significant enough departure from the conceptual site model to warrant alteration of the Phased Injection Approach (i.e., starting with the EIB PRB, as proposed in an email to DEQ dated July 17, 2008[12]) for the purpose of source control. Further investigation of this area can and should occur on a parallel track with the Phase I injections, and impacts will be addressed by subsequent injection Phases.

MGP DNAPL Analytical Data

Manufactured Gas Plant (MGP) dense non-aqueous phase liquid (DNAPL) was encountered in several borings at depths targeted for groundwater sampling. Three samples of MGP DNAPL were collected and analyzed for VOCs by USEPA Method

[11] Pankow, J. F. & Cherry, J. A. (eds) *Dense Chlorinated Solvents and Other DNAPLs in Groundwater,* Waterloo Press, Portland, OR. 1996.
[12] Communication to Dana Bayuk of DEQ from James Peale, MFA.

8260. As shown on Table 4, TCE concentrations varied widely. The high concentration of TCE in sample GP-123-30, like groundwater samples upgradient of the former UST area, suggests a separate, discrete release of TCE into a zone of pre-existing MGP DNAPL. The data from adjacent MGP DNAPL and groundwater samples collected at the same elevation indicates that the lateral extent of impacts from this potential release is limited. Such impacts may, however, contribute to deeper or downgradient detections. These results warrant an expanded investigation, which can occur on a parallel track with the Phase I injections. When fully delineated, this supplemental area could be addressed by subsequent injection phases as necessary.

Source Modeling

MFA utilized the mass estimating tools bundled with Environmental Visualization System (EVS) software to estimate the extent of TCE impacts above the injection threshold. EVS allows use of a kriging functions to predict locations where TCE is present above the injection threshold, effectively bounding the data set by a selected confidence level[13].

While a 95% confidence level is typical for statistical evaluations, requiring this high level of certainty in bounding the TCE injection threshold could result in underestimation of the injection volume, potentially leaving areas of significant TCE impacts outside of the injection zone. MFA therefore selected a lower confidence level (80%) with corresponding standard deviations, and used a maximum plume algorithm in order to conservatively overestimate the injection zone volume. EVS determines at each node a maximum value such that 80% of the time, the actual values will fall below the maximum value established. This methodology determines the maximum area likely to contain concentrations above the injection threshold.

This approach was utilized in the Focused Feasibility Study[14] for MFA's analysis of the lateral and vertical extent of TCE and its degradation products in groundwater at the riverbank. The approach optimizes the injection zone design and reduces the uncertainty inherent in subsurface investigations.

[13] Kriging is a geostatistical method of interpolation that minimizes the estimated variance of a predicted point with the weighted average of its neighbors. At higher confidence levels, the modeling results indicate a higher probability that groundwater at a given point contains TCE at or above a given threshold (in this case, the injection threshold).

[14] As approved by DEQ on February 15, 2008.

Lateral and vertical extent (80% max plume – cross sections)

The lateral extent of TCE above the injection threshold based upon the 80% maximum plume is shown on Figure 3. The boundary line represents the furthest lateral extent in a given direction where TCE concentrations are predicted to be at or above the injection threshold. However, because the source area is characterized by significant variability in TCE distribution in the vertical direction, the area shown on Figure 3 might overestimate the required injection zone.

Figures 4 through 6 depict in cross-section views the extent of TCE above the injection threshold. The cross-sections demonstrate the change in vertical extent between the areas upgradient and downgradient of the former UST area. The cross section shown on Figure 4 represents the approximate alignment of the EIB PRB proposed for Phase I.

ADDITIONAL DELINEATION

Additional delineation is proposed to assist the design of the Phase I PRB and to further the understanding of conditions to the south of the service road. In order to accomplish timely completion of the first phase, these further delineation efforts will be conducted concurrently with the earliest injections for the Phase I PRB. The actual locations of the borings are partly contingent on access.

An additional boring is proposed beyond GP-122 at the western end of the proposed Phase I PRB, as shown on Figure 7. The boring will be sampled at vertical intervals consistent with the previous delineation samples. Results of the samples from this boring will be used to complete the design of the western portion of the Phase I PRB.

A new boring is also proposed in the vicinity of GP-15, to the south of the service road. That boring will be used to further profile soil, potential MGP DNAPL, and groundwater for the presence of TCE. Soil cores will be obtained from the boring between 18 and 35 feet bgs and will be assessed for the presence of MGP DNAPL. Soil and MGP DNAPL samples will be collected. After completing the soil boring, a groundwater screen will be placed at approximately 30 feet bgs to collect a groundwater sample.

Further delineation efforts are likely limited by the presence of underground utilities. Siltronic will conduct additional utility locating activities in the area south of the service road, to increase the resolution of subsurface information that is available.

MONITORING WELLS

The locations and screen elevations of performance monitoring wells (PMWs) to be installed were proposed in the Workplan, and are shown on Figures 7 and 8. In subsequent discussions, DEQ indicated that approval of the locations downgradient of Fab 1 (Figure 8) would be contingent upon the delineation results. The cross-gradient geometry of the plume in the source area is similar to that observed downgradient of Fab 1, with shallower impacts to the southeast, and deeper impacts to the northwest. The proposed riverbank PMW locations reflect this geometry and are consistent with the riverbank and source area delineation results.

Implementation of the full-scale remedy should conform to the pilot study approach. As such, installation of a PRB with monitoring points located with approximately 15-20 feet downgradient will provide timely verification of PRB performance. Without these monitoring wells, evidence of successful treatment would depend on the PMWs located downgradient of Fab 1, which would delay data collection and could confound interpretation.

Accordingly, additional PMWs immediately downgradient of the PRB are proposed for the Phase I EIB. The proposed locations and screen intervals are shown on Figure 7, along with the Phase I EIB PRB alignment. The proposed locations and elevations are intended to provide the necessary performance monitoring data within and downgradient of the Phase I EIB PRB.

The locations are partly dictated by the limited access in the source area. PMW construction will be similar to the pilot study well construction, consisting of 2-inch diameter PVC casings, 10-foot long stainless steel wire-wrap well screens with 1-foot DNAPL sumps, installed using limited access sonic rigs. The PMWs in the source area will be installed after the Phase I PRB is installed.

Based upon the delineation data, the following locations and elevations are recommended:

- Eastern PRB – PMWs are recommended within and downgradient of the EIB PRB near GP-111 and GP-114, with screens located 40-50 feet bgs. An upgradient PMW is not likely practicable due to the overhead pipe bridge in this area and additional utilities and buildings located upgradient. WS-13-69 is reasonably close for the purpose of monitoring upgradient conditions. The optimal location for the downgradient PMW is adjacent to GP-114, given the location of downgradient utilities and access limitations.

- Central PRB – PMWs are recommended upgradient, downgradient, and within the EIB PRB adjacent and slightly west of GP-108/GP-109. These wells should be paired installations, with screens in the 60-70 and 95-105 feet bgs intervals (i.e., similar to the pilot study wells). With the exception of the air compressor tanks located downgradient of GP-109 (against the Fab 1 building), there are fewer access limitations in this area.

- Western PRB – PMWs are recommended upgradient, downgradient and within the EIB PRB adjacent and slightly west of GP-112. Significant access limitations in this area include the pipe bridge and the electrical transformers, limiting the PMW installations to the sidewalk shown on Figure 7. As such, these wells should be single installations, with screens targeted at the highest concentrations in GP-112 (i.e., the 95-105 feet bgs interval).

These proposed locations are intended to provide fairly high-resolution data regarding the performance of the Phase I EIB PRB, and will improve the calculations of degradation rates between the source area and the riverbank.

INJECTION PLAN

As discussed previously, the overriding objective for source control (i.e., delivering "clean" water to the riverbank) is best met by implementing a phased injection approach. MFA recommends installing the Phase I EIB PRB (as shown on Figure 7) at the downgradient end of the source area, consistent with access limitations and the need for the primary PMWs. Potential data gaps related to TCE concentrations upgradient of the former UST area may be addressed on a parallel track (i.e., during installation). The design of subsequent injection phases will incorporate data from further delineation efforts and could include a supplemental PRB located along the service road (Phase II), and hot spot treatment in other areas (Phase III), where accessible.

The horizontal and vertical extents of the Phase I PRB are based on the delineation data (as evaluated using the 3D EVS model) and access limitations. The horizontal length of the proposed Phase I PRB is approximately 175 feet, extending from near GP-118 to west of GP-122. The vertical extent of the proposed Phase I PRB will be targeted to concentrations above the injection threshold, with the eastern portion installed between 42 and 76 feet bgs (-7 and -41 feet MSL), and the western portion installed between 42 and 106 feet bgs (-7 and -71 feet MSL). The plan view of the alignment is shown on Figure 7, and a cross-section along the alignment is shown on Figure 9.

The Phase I PRB will require approximately 96 injection borings. The injection parameters used in the pilot study will be the basis for the full scale implementation, as shown on Table 4. Angled injection borings (as discussed below) will be required for the portion of the PRB under the overhead pipe rack.

As inferred from Figure 3, TCE above the injection threshold may be present downgradient of the Phase I PRB. The source area and riverbank pilot studies confirmed that the EIB PRB approach will be successful, resulting in reduced concentrations of TCE, cis-DCE, and VC downgradient of the injection zone. The pilot study data also demonstrated the presence of dechlorinating microbes and beneficial effects of EIB up to 20 feet downgradient of the PRB injections. Consistent with the recommendations of the Siltronic FFS, the EIB PRB approach is appropriate for reducing concentrations of TCE and its degradation products within and downgradient of the injection zone.

Injection Area Preparation

Prior to beginning injections in the Phase I PRB area, a series of steps will be taken to reduce the risk of encountering underground utilities. First, a private utility locator service will check the area for detectible utility lines. As a second precautionary step, the perimeter borings of the injection grid will be cleared using air knife techniques. Soil removed from the boring will be collected in sealed rolloff boxes for offsite disposal at a permitted landfill facility. The cleared boring location will be backfilled with bentonite chips and topped with a 6 inch layer of gravel.

EHC Injection Method

EHC materials will be injected to the subsurface using GeoProbe® direct-push equipment. Even distribution of materials will be ensured by injecting at 4-foot vertical intervals within each borehole. The injection intervals will be offset 2 feet between rows. The specified amount of EHC will be injected through probe rods equipped with pressure activated injection tips. The injection intervals will be completed in a top to bottom approach. This top-down approach will allow the subsurface pressures associated with the addition of the EHC materials to be distributed deeper into the formation and result in less material being forced back out of the injection hole. Pressure in the formation will be allowed to decrease by waiting a minimum of 4 hours after completing the injection boring before removing the injection rods.

EHC slurry will be produced at the site since EHC is shipped as a dry power. The material is mixed with water to make a 20 to 30 percent solids slurry using a mechanical mixer.

Tap water will be used for mixing the injection slurry. Based on prior results, the iron in the EHC combined with the fermentation of the carbonaceous component of EHC is expected to very effectively scour oxygen from the tap water in a short amount of time, creating the anaerobic environment required by the KB-1.

KB-1 Injection Method

KB-1 innoculum will also be injected using GeoProbe® direct-push equipment. The cultures will be distributed in a bottom up technique at the same 4-foot intervals where the EHC was initially injected. For the microbial injections a standard water sampling screen attachment will be advanced to the bottom and then pulled back to expose the well screen. With the screen exposed to the aquifer, the boring rods will fill with groundwater. Tubing will be advanced down the rods to the well screen depth. A peristaltic pump will deliver the appropriate dose of inoculum through the tubing to the well screen. Anaerobic chase water will be pumped after the inoculums to ensure that the full inoculum dose is delivered to the screen zone. The rods will then be raised to the next injection interval and the process will be repeated. Since the microbe injections do not require high pressures, the rods can be removed immediately upon completion.

The KB-1 cultures require anaerobic conditions and therefore cannot be injected immediately after the EHC injections. A period of at least two weeks will be allowed in any boring between EHC and KB-1 injections. Due to the number of injections being performed, it is unlikely that aerobic conditions will remain prior to KB-1 injection. However, the first interval in each boring will be checked to ensure that dissolved oxygen is below 0.5 mg/l and that oxidation reduction potential (ORP) is below -75 mV.

Anaerobic chase water is a requirement for the successful delivery of KB-1. To provide the anaerobic water a tank will be filled with tap water and a small amount of sodium sulfite will be added to the tank. Dissolved oxygen levels will be monitored on a daily basis and additional sodium sulfite will be added as necessary. The lid on the tank will be closed at all times to minimize potential exposure to oxygen.

Angled Injection Borings

Angled borings will be avoided to the extent possible, due to the increased level of effort, and the increased risk of shearing of boring rods.[15] Rods that shear during the injection process are unlikely to be recoverable. Recovery of injection rods requires overdrilling at the same offset angle, which will be difficult to achieve with available drilling equipment.

In order to facilitate surface access to the source area without the need for angled injection borings, Siltronic has modified their operation and equipment layout to the extent possible. Siltronic has cleared non-critical equipment from the source area, including the aboveground storage tank (AST) farm, air receivers, air conditioning units, and has planned for the future removal of a maintenance building. Remaining equipment is critical to the operation of the facility. The portion of the impacted plume downgradient of the Phase I PRB will be treated by downgradient distribution of EIB components (KB-1 microorganisims and EHC breakdown products), as discussed above.

In the event of infrastructure interference (e.g., the overhead pipe bridge) at any of the planned injection locations, angled borings may still be contemplated as an alternative. The direct push equipment may be operated with a vertical offset of 15 to 30 degrees. If angled borings are required, the injection zone width and required surface offsets for the injection points will be calculated to ensure adequate delivery of materials. A schematic showing angled injection borings in shown on Figure 10.

In comments, DEQ suggested that Siltronic consider angled injection under Fab 1 to address potential impacts above the injection threshold downgradient of the PRB. MFA concurs that TCE may indeed be present under Fab 1 at concentrations above the injection threshold. TCE was similarly detected above the injection threshold downgradient of the pilot study PRB, but those downgradient concentrations were successfully reduced to well below the injection threshold within one year of implementation.

The delineation data also show that the benefits of the pilot study PRB have extended downgradient to GP-108, as evidenced by reductions in TCE concentrations and production of vinyl chloride. The pilot study delineation data thus confirm the operation of the PRB as designed – remediated groundwater and dechlorinating bacteria travel downgradient of the PRB, reducing concentrations of TCE and its degradation products.

[15] Note that significant loss due to shearing was experienced at the riverbank when direct-push rods were either unsupported (as occurred during the riverbank injections) or when deviation from vertical occurred (as experienced during drilling by AMEC on behalf of SLLI).

The potential benefit of attempting injections under Fab 1 in addition to the PRB is not clear, and may not be demonstrable using data from downgradient PMWs (i.e., downgradient of Fab 1). Injection downgradient of a PRB is not generally proposed as a matter of practice, since it would confound interpretation of "downgradient" data (which by definition would no longer be downgradient). Likewise, injection downgradient of the PRB would preclude installation of the PMWs to be installed between the PRB and Fab 1. Since timely demonstration of source area treatment requires installation of PMWs a short distance downgradient of the Phase I PRB, injection under Fab 1 is not recommended.

Injection Boring Completion

Upon completion of both the EHC and KB-1 injections at a boring, the boring will be abandoned using bentonite slurry that is applied from an approximate depth of 30 feet bgs. This alternate method of abandonment is consistent with the pilot study approach, which was approved by the Oregon Water Resources Department.

Implementation Schedule

The injection schedule for Phase I will be completed in sequential steps with only a small amount of overlapping tasks. The conceptual schedule is presented as Figure 11. The first step will be to perform the utility location and air knife the perimeter borings. Air knifing is expected to require approximately 2 to 3 weeks. Once a sufficient number of borings have been cleared, EHC injections will begin. EHC injections will be carried out by one or two direct push drill rigs, and should require approximately 6 weeks to complete.

KB-1 injections will begin immediately after EHC injections are completed. The KB-1 injections will be completed in the same order as the EHC injections to ensure that optimal conditions have developed for the microorganisms. Completion of each injection boring will occur immediately after the completion of KB-1 injection at that boring. KB-1 injections are expected to require approximately 4 weeks. If work is approved to begin in mid-September, completion of the Phase I PRB is expected to occur by mid-December.

Siltronic is looking forward to making progress toward source control and appreciates DEQ's efforts in reviewing and commenting on this and other documents. Please call either of us at (971) 544-2139 if you have questions or comments.

Sincerely,

Maul Foster & Alongi, Inc.

REGISTERED PROFESSIONAL ENGINEER
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Attachments: Figures
Tables
Attachment 1 – Slug Test Results
Attachment 2 – Permeability Test Report
Attachment 3 – Validation Memo and Laboratory Reports (CD)
Limitations

cc: Tom McCue and Myron Burr, Siltronic
Chris Reive, Jordan Schrader
Alan Gladstone and William Earle, Davis Rothwell Earle & Xochihua, P.C.